# Economic analysis of Eskom's energy-efficient lighting programme for low-income households

ALIX CLARK

October 1997
ENERGY AND DEVELOPMENT RESEARCH CENTRE
University of Cape Town

# Table of contents



## List of tables

# 1. Introduction

This is the fourth report in a series of papers produced by the Energy and Development Research Centre (EDRC) on energy-efficient lighting. The research falls under EDRC's Energy Efficiency, Equity and Environment project which is co-sponsored by Eskom and the International Development Research Centre, of Canada.

Though Eskom's Energy-Efficient Lighting (EEL) Programme is new, and very little empirical data is available, it is important for strategic planning processes to assess, at this early stage, the potential economic costs and benefits of the programme. This paper presents an analysis of the EEL programme for urban low-income households from the point of view of the national economy, households, and Eskom itself. Economic, socio-economic and environmental aspects of the programme are taken into account. The report builds on the results of the financial analyses already undertaken by Eskom regarding energy-efficient lighting, and also makes use of the other reports written for this series, namely, `Compact fluorescent lamps in an international context', `Energy-efficient lighting in an imperfect market: Preliminary thoughts for South Africa', and `Strategy for Eskom's energy-efficient lighting programme'. The last paper has particular relevance for the socio-economic and environmental impacts of the programme.

Section 2 below briefly introduces Eskom's energy-efficient lighting programme. In section 3, the overall analysis of the programme is presented; it is divided into the following four sections: `Structure and basis of the analysis', `Economic analysis from a national perspective', `Economic analysis from a customer perspective', and `Economic analysis from Eskom's perspective'. Conclusions follow in section 4.

# 2. Eskom's energy-efficient lighting programme

The National Electricity Regulator (NER) has committed the electricity distribution industry (EDI) to targeting 450 000 new connections in South Africa annually. In doing so, it aims to raise the percentage of electrified households in South Africa from 35% in 1992 to 70% by 2000 (NER 1995). Eskom currently has sufficient capacity until 2007, given this committed construction plan (IEP5), and energy efficiency is thus not an immediate priority from an Eskom generation-capacity perspective (Eskom 1996a). A study of 32 energy-efficiency programmes suggests, however, that a reduction in peak load of 2 500 MW is achievable by 2015 at a life-cycle cost which is considerably lower than that of an equivalent power station. Furthermore, customers participating in the programme could realise a R8 million benefit through reduced electricity costs. In addition, at least 80% of the cost of the energy-efficiency programme (R3.5 million) would be recoverable from participating customers (Eskom 1996b)

Eskom's immediate focus is on the residential sector, which has been targetted because of the nature of its consumption: residential load (demand) constitutes 75% of the total national variable load (demand) and is increasing due to the impact of electrification (Eskom 1997a). Efficiency improvements in this sector could clearly contribute to a reduction in peak demand. These residential efficiency programmes now form the basis of the residential demand-side management (RDSM) programme and include water-heating load control, time-of-use tariffs, thermal efficiency, appliance labelling, energy-efficient behaviour, limited supply capacity tariff options (for electrification), and energy-efficient lighting.

The main objective of the energy-efficient lighting programme is to introduce cost-effective energy-efficient lighting schemes into all residential sectors, and to reduce the evening peak by at least 770 MW by 2015, depending on the developing balance between system supply and demand. The reason that the residential sector has been targetted is that it is largely responsible for the peaky nature of the national load profile.

Specific objectives of the EEL programme (all sectors) are as follows:

- to launch a pilot programme to verify the viability of the programme;
- to make CFLs widely available at affordable prices;
- to improve customer service by reducing houshold lighting cost;

- to contribute to Eskom's RDP commitment towards conserving the environment; and
- to support the macro-economic development of the country (for instance local manufacturing, job creation, foreign-exchange savings) (Eskom, 1997a).

The EEL team proposes to implement this programme over time. In the short term, a gradual awareness of the concept of energy-efficient lighting with low penetration levels in the residential sector will be pursued with a view to evaluating the probably impact of the programme on local demand curves. In the medium term (to 2005), the EEL team envisages a progression towards aggressively marketing the concepts of energy-efficient lighting in the residential sector in anticipation of a pending shortage in capacity. In the long term, the EEL team aims to have a fully-fledged package, with various components suited to the needs of all stakeholders, for the reduction of peak-load demand in a scenario where no surplus capacity is available in South Africa (Eskom, 1996a).

The programme allows for a range of specific DSM activities to be initiated in the low-, middle-, and upper-income sectors. Eskom expects that the programme can achieve MW peak demand reductions (as shown in Table 1) in all three of these market segments, and reports impressive potential savings (net present values) to both its customers and to the utility. Clearly these savings will depend on the number of CFLs that the EEL team is able to distribute in the time periods given above.

| *Sector* | *MW - 2000* | *MW - 2015* |
|---|---|---|
| High-income | 90 | 500 |
| Middle-income | 30 | 90 |
| Low-income | 20 | 90 |
| **TOTAL** | **140** | **680** |

**Table 1:** Projected peak demand reductions
*Source: Eskom 1996b*

The analysis to follow deals in particular with potential impacts of the energy efficient lighting programme targetted at the *low-income sector*.

# 3. Economic analysis

The economic analysis contained in this report is divided into three sections. The first examines the EEL programme from a national perspective, the second from the perspective of prospective programme customers, and the third from Eskom's perspective. These analyses are presented in sections 3.2, 3.3, and 3.4 respectively. In each of these sections, economic, socio-economic and environmental impacts of CFLs are discussed.

## 3.1 Structure and basis of the analysis

As noted in section 2 above, the EEL programme for all sectors is relatively new. Eskom is currently developing a strategy for the programme, and plans to launch a number of pilot projects to test the impact and acceptability of energy-efficient lamps in various household sectors. To date, little empirical analysis has been undertaken. Essentially, this cannot be done until the pilot projects are implemented, and impacts, such as the real savings to Eskom, local service providers, and customers are evaluated. Where this data is not available, or is not easily accessible, assumptions have been made. Care has been taken to detail the methodology and stages of the analysis so that, if the assumptions made are deemed unrealistic or if a sensitivity analysis is called for, the calculations can be easily re-worked.

Assumptions that are more specific to a particular aspect of the analysis are made where most relevant, appear in where most relevant, and are numbered 1 to 15 within sections 3.2 to 3.4. Broad assumptions underlying this analysis are detailed in this sub-section.

Each of the following sections – that is, the economic analyses from national, customer and Eskom perspectives – have a similar structure. The first sub-section of each of the analyses calculates the net annual quanifitable benefits or costs of installing a CFL. For the national and Eskom perspectives, these costs and benefits are translated into the `cost of conserving a unit of electricity (CCE)', and the `cost of avoided peak installed capacity (CAPIC)'. The methodology used borrows from that developed by Gadgil and Jannuzzi (1991) and Krause (1988). The EEL team has yet to set firm targets for the programme, so these concepts are particularly useful to this analysis, where *unit* impacts are examined. The second and third sub-sections of each of the analyses discuss other less easily quantifiable costs and benefits (mainly socio-economic and environmental) to the national economy, customers and Eskom.

Eskom's EEL programme for low-income households will target two different markets: newly electrified and previously electrified households. It is assumed that the newly electrified households are less established, and that householders will initially invest in one energy-saving lamp per household. Previously electrified households may, on the other hand, have more than one operating lamp. The programme will target the most heavily-used lamp(s) in the household. So, the peak co-incidence rate for the incandescents targetted for replacement will be higher than the rate for the average lamps in the household. It is assumed here that the CFLs installed will have a co-incidence rate of disuse that is half that of the average incandescent bulbs in the household. It is further assumed that the average incandescent used in low-income households has a peak-coincidence use rate of 40%, so 60% are peak-coincidently in disuse. Thus, the CFLs introduced will have a disuse coincidence with the system peak of half of this – that is, 30%. In other words, 70% of the energy-saving lamp wattage will be in use peak-coincidently.

International experience shows that low-income households are not adequately satisfied with lamps that emit low levels of light.[1] Though the EEL team has considered installing 9 W CFLs, it has been assumed in this analysis that 15 W CFLs (for the glass element and the base) will be made available to both newly electrified households and previously electrified households in the low-income sector. Clearly the energy savings the end-user and Eskom will capture will be less than if lower wattage lamps were used, yet the savings are *still* significant for Eskom and the user, and indirect economic benefits (for example, quality of life and customer acceptabilities) will be enhanced.

Predominant benefits of the programme to both the newly and previously electrified low-income households will include energy savings arising from choosing to lamp households with CFLs as opposed to incandescent lamps, as well as the socio-economic spin-off effects arising from increased access to lighting for customers, and efficient-use of new peak demand for Eskom.

In this analysis, it has been assumed that a 15 W CFL would produce about the same light output as a 75 W incandescent bulb.[2] As it is unlikely that the previously electrified households targetted by the programme were using 75 W incandescents before (or that newly electrified households would choose to purchase 75 W incandescent lamps), energy-saving calculations using this equivalent will be inflated. To correct this, it has been assumed that a 15 W lamp will be replacing a 60 W incandescent. This means that approximately 45 W (or 45 kW for 1 000 hrs of annual use) will be saved at the socket (i.e. in the household). Taking transmission and distribution losses (assumed here to be 10%) into account, this equals energy savings of 50 W (or 50 kW of annual use) at the power station. But, only a fraction (70% as noted above) of the installed CFLs will be in use peak-coincidently.[3] The average CFL therefore saves 35 W (or 35 kW annually) at the power station. This can be translated into avoided installed capacity by dividing it with a factor that scales for reliability effects (assumed here to be 89%). Avoided peak installed capacity per CFL is thus 39.33 W.

1 See Clark (1997a), (1997c)

2 Clearly though, the exact equivalent will depend on the particular type of technology used.

3 A plant availability factor (a reserve margin) could also be included here.

## 3.2 Economic analysis from a national perspective

### *3.2.1 Economic benefit*

In the national perspective, any subsidies on the lamp do not appear in the analysis on a per unit basis, as any transfer of value as subsidy remains an internal transaction within the national economy. A similar argument can also be made for omitting from the analysis the loss of revenue as a result of decreased sales.

To determine the net present value of one lamp to the economy, the annualised investment cost of a CFL, the investment cost of incandescents for one year, and the avoided generation expenditure for one year should be calculated.

**Assumptions (1)**

1. Before subsidies, the installed cost of a CFL is R50.
2. The average CFL lasts for 10 000 hours (10 years). This translates into 1 000 hours of use per annum, or about 3 hours per day.
3. The social discount rate is 10%, reflecting society's preferences for consumption today.
4. ~~The inflation rate is 10%.~~
5. The average cost of an incandescent is R2.50.
6. The average incandescent lamp lasts for 750 hours which implies that about 1.3 bulbs are used annually.
7. ~~The long-run marginal cost of on-peak electricity varies significantly, but is assumed to be R0.35/kWh, based on a wide range of values.~~

discount period. 10yrs

*CFL annualised investment cost*[4] *= cost of investment x capital recovery rate:*

where,

capital recovery rate, $r = d/[1-(1+d)^{-n}]$

where,

d: discount rate

n: life of the lamp

Annualised cost = 50 x [0.1/1 – (1 + 0.1) $^{-10}$] = R8.14 ...(1)

In other words, if the cost of the CFL is recovered over ten years, R8.14 (present value terms) can be apportioned each year.

*Annual cost of incandescents = net cost of investment x number used per year*

Annual cost of incandescents = R2.50 x 1.3 bulbs per annum = R3.25 ...(2)

*Avoided generation expenditure = generation saved x marginal generation costs*

Avoided generation expenditure = 50 W x 1 000 hrs/year x R0.35c/kWh = R17.50 ...(3)

Therefore, the net benefit of a CFL = (2) + (3) - (1)

**Net present benefit to the economy of one CFL installed this year = R12.61 ...(4)**

This implies that if Eskom were to install 500 000 bulbs per year into this sector, the net present benefit to the national economy would be approximately R6.3 million *in the first year.*

It is also useful to calculate the Cost of Conserved Energy (CCE) from this same perspective. It is a measure, amortised over the amount of electricity saved, of the cost of conserving a unit of electricity.

here

4 A premium on foreign exchange could be included but has not been. It is felt that the number of CFLs potentially imported is not significant enough to do so. Perhaps when the programme gains momentum, and the demand for CFLs increases to such an extent that it makes financial and economic sense for CFLs to be produced locally, this calculation should be reworked to include this ~~cost to the economy.~~ potential opportunity cost to the economy.

*CCE is the ratio of (4) to the annual electricity saved by the lamp at the generation point*
**CCE = - R12.61/(35 W x 1000 hours per year) = - R0.36/kWh** ...(5)

In other words, if this conservation measure were implemented, the national economy will receive a *benefit* of R0.36/kWh.

The net present value of a conservation measure leading to an avoided installation of a kW of generation capacity (for the life of the power plant) leads to the concept of the `cost of avoided peak installed capacity', CAPIC. The measure is calculated taking account of investment costs, the avoided purchase of incandescent lamps and also avoided generation expenditure.

**Assumption (2)**

8. The life of an average power station is 30 years.

CFL annualised investment cost = cost of investment x capital recovery rate

Since the inflation rate has been assumed here to be the same as the national discount rate (i.e. 10%), the present value of the annualised investment cost of the measure will be the same for 30 years as it has been calculated for 10 years (i.e. R8.14)

*Annual cost of incandescent = net cost of investment x amount used per year*
Annual cost of incandescent = R2.50 x 1.3 bulbs per annum = R3.25 ...(2)

*Avoided generation expenditure = generation saved x marginal generation costs*
Avoided generation expenditure = 50 W x 1 000 hrs/year x R0.35c/kWh = R17.50 ... (3)

*Net present benefit of a CFL = (2) + (3) - (1)*
**Net present benefit to the national economy (30 years) = R12.61 for this year** **...(4)**

To avoid installing peak capacity, interventions must last as long as the life of the plant (assumed to be 30 years) as well as the 10 years before the plant is built. Economic benefits must therefore be assessed over this entire time period to determine the cost of avoided peak installed capacity.

NPV (R12. 61, 10%, 40 years) = R65.04 ...(5)

*CAPIC is the ratio of (5) to the installed capacity saved:*
**CAPIC = - R65.04/(39.33 W x 1000 hrs/year) = - R3441.14/kW** **...(6)**

This result is interesting on two accounts. Firstly CAPIC is negative, which indicates a benefit to the national economy. Secondly, if the CAPIC for this energy-efficeincy investment is lower than the cost of new peaking plants, the efficiency investments should be given priority. In South Africa, installing peaking plant capacity costs between R3 000 and R5 000/kWh. There are thus substantial benefits for the national economy from implementing the conservation measure as opposed to investing in another power plant.

### 3.2.2 *Health and environmental impacts*

In South Africa over 70% of all electricity is generated from coal. As such the major environmental impact of introducing CFLs can best be measured with reference to the savings made at coal-fired power stations. A single 18-watt CFL can save over its lifetime (Lovins 1990):

- a ton of carbon dioxide
- 4 kgs of sulphur dioxides
- 1 kg of nitrogen oxides, among other emissions from a coal fired plant.

Assuming that, in South Africa, 475 tons of coal produces 1 GWh of electrical energy, a single 18-watt lamp will require, over its lifetime, approximately 85 kg of coal, and will save about 250 kg of coal that would have be used had an incandescent lamp been operated instead.

CFLs also avoid the combusion of mercury-containing fuels used to make electricity. Including the mercury contained in the fuel used to generate the electricity, total life-cycle mercury releases would be approximately 9 mg/CFL if coal is used. However, 20 mg of mercury emissions would be avoided compared with the case of using inefficient incandescent lamps (Mills, 1991).

#### 3.2.3 *Macro-economic impacts*

One of the objectives of the EEL programme, as noted in section 2 above, is to 'support the macro-economic development of the country'. Interestingly, this objective could be achieved not so much currently as in its *potential* contributions to the macro-economy. Currently, there are no local CFL manufacturers in South Africa and Eskom imports all of the lamps that it distributes. In the calculations of CCE and CAPIC above, a premium on scarce foreign exchange resources has not been provided for: it has been assumed that the numbers of CFLs *currently* being imported will not have significant impact on the level of foreign exchange. As the programme picks up speed, and as more CFLs are distributed and demanded, it might be worthwhile factoring in this additional impact. It is also hoped that the demand for CFLs will increase to such an extent that a market share for CFLs can be proven, in which case it is possible that a lamp manufacturer might choose to produce CFLs locally. This development could have marked spin-off effects, particularly for job creation and in local economic development.

Rigorous adoption of cost-effective energy efficiency, in general, could also reduce the energy-intensity of the South African economy. This would have environmental implications (reduced emissions), and also for energy security(reduced dependence on local and global natural resources).

## 3.3 Economic analysis from a customer perspective

#### 3.3.1 *Economic costs*

The cost and benefits that the customer incurs depends on the price of electricity, and any subsidy that Eskom may offer towards the purchase of the CFL. The calculations here are based on the cusomter purchasing electricity for R0.26/kWh. Different levels of subsidy are calculated.

**Assumptions (3)**

9. The social discount rate is 35% reflecting the tight income constraints faced by the poor.
10. The discount period is 10 years for the life of the lamp.
11. The value of the replaced incandescent is zero. If the customers choose to re-sell the incandescent, the benefits of replacing it will be augmented in the first years. If the customers choose to install the replaced incandescent elsewhere, energy costs will obviously rise.

*Net annual customer cost of buying one CFL = saved electricity per annum + avoided cost of incandescents – CFL investment costs.*

Electricity saved = 45 W x 1000 hrs x R0.26c/kWh = R11.70 per year ...(7)

Avoided cost of incandescents = R 3.25/year ...(2)

??! CFL annualised cost = R18.42/year ...(8)

where,

$r = 0.35/ [1 - (1.35)^{-10}] = 0.37$

**The net present cost to the consumer buying an unsubsidised CFL is R3.47. ...(9)**

If Eskom were to subsidise 20% of the lamp, then the customer would receive a net present benefit of R0.15 for the one lamp. Similarly, with a subsidy of 25%, customers' benefit would be R1.08 per lamp per year. If Eskom were to subsidise 19% of the lamp (that is, the customer would purchase the lamps for R40.41) the customer would break even. In order for prospective customers to become interested in the programme, Eskom would have to subsidise the cost of the lamp by *at least* this amount (that is, 19%).

### 3.3.2 *Possible 'take-back' effects*

It is possible that customers, having installed more efficient lighting, will choose to re-direct some of the freed up capital on improving their energy services. This could mean that they would choose to install another lamp. The calculations are all based on the economics for the net present value of one CFL so any 'take-back' effect can be easily assimilated. Customers might choose to use the CFL invested in for longer periods of time each day - for instance, four hours per day instead of three. The calculation to follow is for a CFL that lasts eight instead of ten years.

CFL annualised cost = R 19.50

where,

$r = 0.35/[1 - (1.35)^{-8}] = 0.39$

valued Electricity saved declines from R11.70 each year to R8.76 (with 1 250 hours of usage).

Thus, without a subsidy, the customer would incur a net cost of R7.49 each year. With a 20% subsidy, the cost would be decline to R3.59 per year. The customer would break even with a 61% subsidy (that is, buying the lamp for approximately R20.00).

### 3.3.3 *Socio-economic impacts*

In addition to a greater level of household income being directed towards improving energy services (see section 3.3.2 above), saving on energy costs could also allow for a greater percentage of household income to be directed towards other household services – food, health, education, job search and housing. In addition, much of this 'freed-up' capital can, and would most likely, be re-invested in the local economy. In essence, energy savings can have a multiplied effect – not only for the household concerned but also for the local community.

Related also to potential energy savings, CFLs can also enable more households to take advantage of electricity, and electrical lighting. This is because CFLs essentially reduce the cost of monthly household energy bills. Clearly, if it less costly to operate a CFL than an incandescent lamp, a larger market demand will develop. The benefits of lighting have been very well documented, and as such will not be expanded upon here. Suffice to say, lighting can enhance the development process by enabling people to be more productive when the sun goes down.

CFL investments can also be costly to low-income households. Given that the CFL will be the only source of light in many households, it is reasonable to assume that the lamps will be moved around constantly. Firstly, then, households choosing to use these lamps run the high risk of breakage. When Eskom starts to distribute lamps, it will probably offer a warranty on the lamps that it sells. It is likely that the warranty will only extend to lamps breaking for technical reasons, and not as a result of household accidents. CFLs broken as a result of household accidents represent a significant economic loss to households.

Secondly, in many parts of South Africa low-income households use domestic lighting not only for light: incandescent bulbs emit a source of heat, though small, that has become valuable in many households unable to afford conventional heating methods. CFLs are cool, operating at significantly lower temperatures than incandescent lamps. Replacing incandescent lamps with CFLs thus implies that households might need to consider other forms of heating, which has implications for the distribution of household income, or accept the lower evening temperatures.

### 3.3.4 *Health and environmental impacts*

In South Africa, provision is yet to be made for households to dispose of spent or broken lamps. As elsewhere in the world, concern is being expressed about the uncontrolled releases of mercury emitted when CFLs are thrown away. In some low-income areas, refuse is not collected regularly, if at all. Children play in refuse, garbage pickers earn their living from sifting through refuse, and animals graze in these areas. Every CFL contains about 5.5 mg of mercury. Where small quantities of these lamps are thrown away, it is unlikely that there would be significant impact on human health and the environment. If millions of lamps are disposed of, the impacts would clearly become more concerning, and should not be underestimated.

## 3.4 Economic analysis from Eskom's perspective

### *3.4.1 Economic benefits*

To determine the net present value of one lamp to Eskom, the value of avoided generation expenditure for a year, the annualised value of the subsidy offered by Eskom and the loss of revenue from decreased sales must be calculated.

*Net benefit this year = avoided generation expenditure – subsidy offered for CFLs – loss of revenue from decreased sales.*[5]

**Assumptions (4)**

12. The subsidy offered by Eskom will be 20% of the price of the lamp.
13. Eskom's discount rate is 6%.
14. The discount period is ten years, again for the life of the lamp.

*Avoided generation expenditure = generation saved x marginal generation costs*

Avoided generation expenditure = 50 W x 1 000 hrs/year x R0.35c/kWh = R17.50 ...(3)

*Cost of subsidy offered for one CFL = cost of lamp x Eskom subsidy*

Cost of subsidy = R50.00 x 20% = R10.00

Annualised cost of subsidy = R1.36 ...(10)

where,

$r = 0.06/(1 - (1.06)^{-10} = 0.1359$

*Loss of revenue from decreased sales = electricity saved at socket x price of electricity*

Loss of revenue from decreased sales = 45 W x 1 000 hrs/year x R0.26c/kWh = R11.70

...(7)

*Net present benefit of an operating CFL to Eskom = (3) - (10) - (8)*

**Without taking the costs of the EEL programme (e.g. promotional and administration) into account, the net annual benefit (NPV) of one CFL to Eskom with a 20% subsidy is R4.44.** ...(11)

26c

50/4 x tariff

(5*(39-

In fact, if Eskom chooses to give the R50 lamps away, it would only incur costs of R0.79 per lamp.

If Eskom were to distribute 500 000 lamps (20% subsidy) per year, Eskom would save approximately R2.2 million in the first year. This amount would rise exponentially each year as lamps installed in previous years would still be operating, using less energy.

If the possible 'take-back' effects, as noted in section 3.3, are taken into account, avoided generation expenditure will be reduced to R13.13, the annual cost of the subsidy will be R1.61, and the revenue lost from reduced sales will be R8.77. The net annual benefit of one CFL to Eskom with a 20% subsidy is R2.75.

---

[5] The annual cost of the programme should also be taken into account here, if the true annual benefit to Eskom can be estimated. In this analysis, programme costs have been omitted because the data in the documentation made available is inconsistent. Programme costs (excluding capital costs) range between R140 000 (Eskom, 1997d) and R7 million (IEP5) per year.

*CCE = net benefit this year / annual energy saved*
**CCE = - R4.44/35 W x 1 000 hrs/year = - R0.13/kWh** **...(12)**

Finally, we calculate CAPIC:

**Assumptions (5)**

15. The discount period is 30 years, for the life of a power plant

*Avoided generation expenditure = generation saved x marginal generation costs*
Avoided generation expenditure = 50 W x 1 000 hrs/year x R0.35c/kWh = R17.50 ...(3)

Cost of subsidy offered for one CFL = R10.00

Annualised cost of subsidy (30 years) = R0.73 ...(13)
where,
$r = 0.06/[1-(1.06)^{-30}] = 0.073$

Loss of revenue from decreased sales = 45 W x 1 000 hrs/yr x R0.26/kWh = R11.70 ...(7)

*Net present benefit of an operating CFL to Eskom = (3) - (13) - (7)*
**The net benefit of one CFL to Eskom is thus R5.07 for this year** **...(14)**

NPV (5.07, 8%, 40 years) = R65.04 ...(15)

*CAPIC is the ratio of (15) to the annual electricity saved by the lamp at the generation point.*
**CAPIC = - R65.04 /0.03933 kW = - R1 628.50/kW** **...(16)**

Again CAPIC is negative, indicative of a benefit to Eskom. Given that it costs Eskom between R3 000 and R5 000/kW to install new capacity, it makes economic sense for Eskom to implement this conservation measure.

### 3.4.2 *Environmental impacts*

In section 3.2.2 above, the environmental benefits from a national perspective of introducing CFLs into the low-income sector were briefly described. In the light of Eskom's efforts towards improving its environmental practices and contributing towards the government's commitment towards conserving the environment, it is important to take account of these benefits from its point of view as well. Interestingly, CFLs represent a clear cut mechanism for Eskom to reduce its emissions at a profit not only to itself, but also to its customers.

### 3.4.3 *Social impacts*

As explained in more detail in Clark (1997c), the EEL programme represents an opportunity for Eskom to improve its relationship with its customers. Low income households, in particular, have had very little interface with Eskom to date. It could be argued that this lack of contact has contributed towards the poor levels of payment for services rendered. The EEL programme represents a perfect example of how Eskom, through choosing to provide a service to the sector (as opposed to a product) could help to improve upon customer image, and hence on the payment records.

## 4. Conclusion

Installing CFLs in low-income households has been shown to have net economic benefits to the national economy and to Eskom, even if the lamps are subsidised. It does not make economic sense, however, for households to invest in energy efficient lighting unless it is subsidised. Table 2 illustrates these results in more detail.

| | National economy | Households | | | | Eskom | | |
|---|---|---|---|---|---|---|---|---|
| | | *No take-back effects* | | *Take-back effects* | | *Subsidy (20%)* | | ~~*Subsidy (100%)*~~ |
| | | *No subsidy* | *Subsidy (20%)* | *No subsidy* | *Subsidy (20%)* | | | |
| | | | | | | *No take-back effects* | *Take-back effects* | |
| Net annual cost for one CFL | - R12.61 (benefit) R4.06 (cost) | ~~R3.47~~ benefit -1.39 | ~~-R0.15~~ (benefit) -4.12 | R7.49 2.15 cost | R3.59 -0.70 benefit | ~~-R1.44~~ (benefit) -1.02 | ~~-R2.75~~ (benefit) 0.53 | - R0.79 (benefit) |
| Net annual cost for 500 000 CFLs | - R6.3million 2million (cost) (benefit) | - | - | - | - | ~~- R2.2million~~ R510 000 (benefit) | ~~-R1.38million~~ 265 000 (benefit) | R395 000 |
| CCE | - R0.38/kWh (benefit) (0.12) | - | - | - | - | ~~- R0.13kWh~~ -R0.02 (benefit) | -R0.03 - | - |
| CAPIC | -R3 441.14 R1 071.66. /kW (benefit) | - | - | - | - | ~~- R1628.52/kW~~ -R215.27 (benefit) | - -412.95 | - |

**Table 2:** Summary of findings of the economic analysis

In addition to the above, installing CFLs into the low-income sector can have considerable other socio-economic and environmental implications. Benefits include reduced greenhouse gas emissions, reduced dependence on natural resources, job creation, local economic development, freed-up household income for improving energy and other necessary services. Potential costs to households include those arising from human exposure to mercury, and from accidential lamp breakages. Clearly though the overall benefits outweigh the benefits.

### *References*


Clark, A 1997a. Compact fluorescent lamps in an international context. Research report. Energy and Development Research Centre: University of Cape Town, South Africa.

Clark, A 1997b. Energy efficient lighting in an imperfect market: Preliminary thoughts for South Africa. Research report. Energy and Development Research Centre: University of Cape Town, South Africa.

Clark, A 1997c. Strategy for Eskom's energy efficient lighting programme. Research report. Energy and Development Research Centre: University of Cape Town, South Africa.

Eskom, 1996a. Demand-side management alternatives to system expansion. IEP5. Eskom: Johannesburg.

Eskom, 1996b. Energy efficient lighting in the SA residential sector: Programme strategy. Revision 2. Eskom: Johannesburg.

Eskom 1996c. Draft DSM planning framework. Revision 1. Eskom: Johannesburg.

Eskom, 1997a. Electricity efficient lighitng pilot programme 1997. Eskom: Johannesburg.

Eskom, 1997b. Synopsis of the integrated electricity plan for Eskom's 1997 – 2001 business cycle. Eskom: Johannesburg.

Eskom, 1997c. Residential demand-side management: Compact fluorescent lamps programme strategy. Draft 3. Eskom: Johannesburg.

Eskom, 1997d. Individual projects active in 1998. Research strategic direction report. Eskom: Johannesburg.

Friedmann, R 1996. Electric efficiency in Mexican households: Implementation issues and savings potential. Dissertation.University of California, Berklely: USA.

Gadgil, A & Jannuzzi, G 1991. Conservation potential of compact fluorescent lamps in India and Brazil. *Energy policy*. June. 449-463.

Geller, H, DeCicco, J & Laitner, S 1997. Energy efficiency and job creation. Email: http://solstice.crest.org/efficiency/aceee/pubs/ed922.htm.

Krause, F et al. 1988. Analysis of Michigan's demand-side electricity resources in the residential sector. Research report nos 23025, 23026, 23027. Lawrence Berkley Laboratory: University of California, Berkeley, USA.

Lovins, A 1990. How a compact fluorescent lamp saves a tone of $CO_2$. Research report #90-5. Rocky Mountain Institute, Colorado: USA

Mills, E 1991. Evaluation of European lighting programmes. Energy policy. April. 266-278.

Mills, E 1992. The World Bank moves towards Mexican CFL loan. IAEEL newsletter.2/92.

Mills, E 1993a. Efficient lighting programmes in Europe: Cost effectiveness, consumer response, and market dynamics. *Energy*. 18(2): 131-144.

Mills, E 1993b. A trillion dollar appetite for electricity. *IAEEL newsletter*. 1/93.

Pye, M 1996. Energy efficiency programs for low-income households: successful approaches for a competitive environment. Email: htp://solstice.crest.org/efficiency/aceee/pubs/u964.htm.

Results Centre 1992. Burlington electric department: Smartlight. Profile # 3. Washington DC: USA.

Weizsacker, E, Lovins, A & Lovins H 1997. Factor four: Doubling wealth, halving resource use: The new report to the Club of Rome. Earthscan: UK.

# APPENDIX

## CCE

The CCE is the annualised cost of implementing an efficiency measure, divided by the annual energy savings. It is defined by the following formula:

CCE = A/B
where,
A = Σ(investment) x (its capital recovery rate) + net increase in annual O/M (operation and maintenance) cost

B = annual energy saved, kWh

The capital revery rates, *r*, annualise the investments. In terms of the discount rate (in current currency), *d*, and the lifetime, *n*, it is given by the expression:

$$r = d/(1-(1+d)^{-n})$$

## CAPIC

CAPIC is the present value of the conservation measure operated over the life of an avioded conventional peak power plant, which is taken to be 30 years. The formula is:

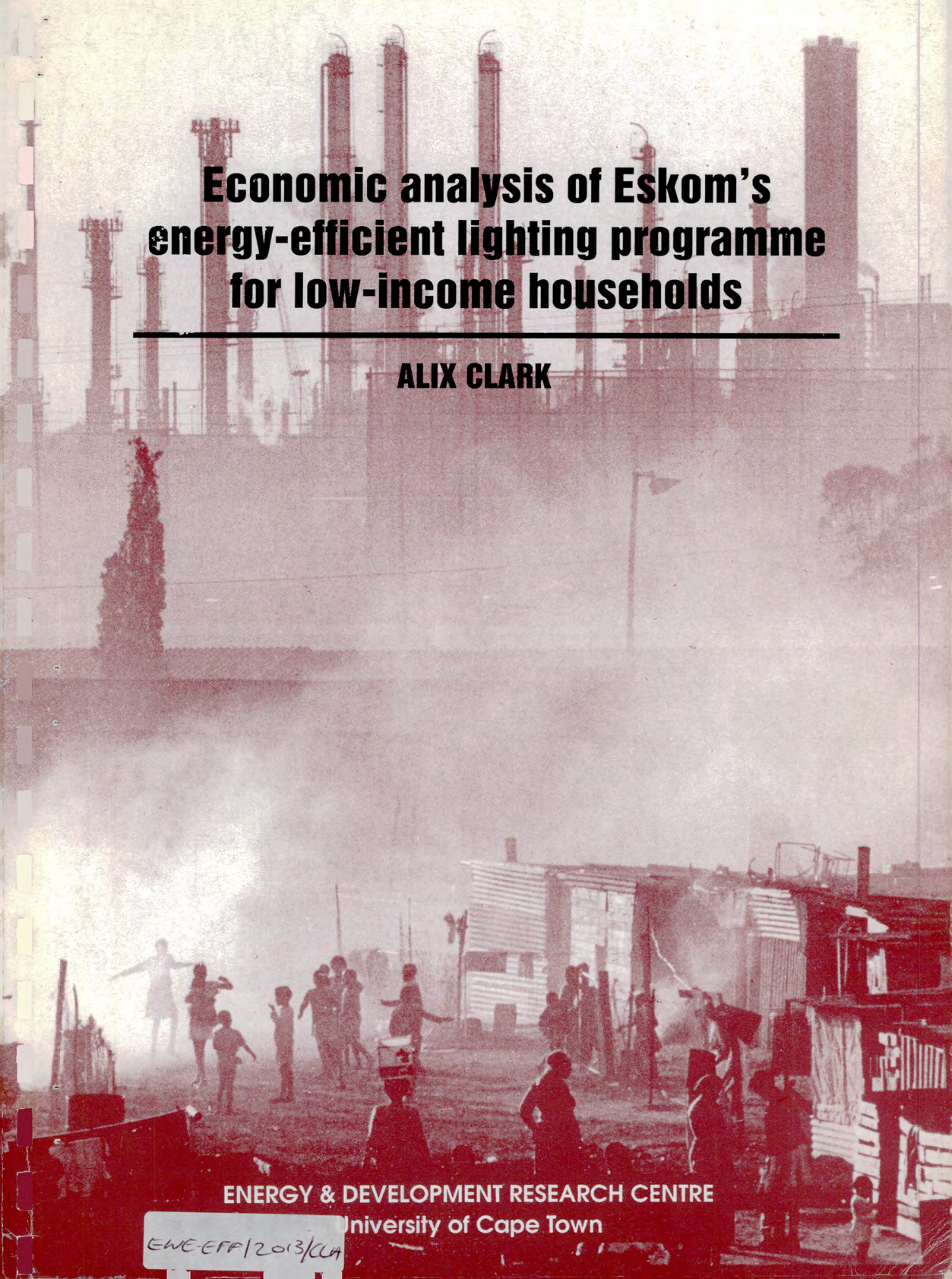
CAPIC = C/D
where,
C = NPV of (investment + net increase in O/M costs) over 30 years
D = installed capacity saved, *kW*.

These definitions originate in Gadgil and Jannuzzi (1991), and Krause (1988).

EDRC REPORT SERIES

# Economic analysis of Eskom's energy-efficient lighting programme for low-income households

ALIX CLARK



ENERGY & DEVELOPMENT RESEARCH CENTRE
University of Cape Town